

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, MASAKI KATOH, a citizen of Japan residing at Kanagawa, Japan, YUKI NAKAMURA, a citizen of Japan residing at Kanagawa, Japan and KATSUYUKI YAMADA, a citizen of Japan residing at Shizuoka, Japan have invented certain new and useful improvements in

OPTICAL INFORMATION RECORDING MEDIUM AND
RECORDING APPARATUS

of which the following is a specification:-

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to an optical information recording medium and a recording apparatus, and, in particular, to an optical information recording medium and a recording apparatus for high-speed recording.

2. Description of the Related Art

10 Recently, high-speed recording has been rendered for an optical information recording medium such as a write-once compact disk (CD-R), a rewriteable compact disk (CR-RW) or the like, to which a light beam is applied so that a material of a recording layer
15 thereof is changed, and, thereby, information is recorded thereto. Further, there are optical information recording media produced for recording at multiple speeds to which recording can be made at an arbitrary speed, and, for which it has been requested
20 that a quality in recorded signal obtained from being recorded at a high speed is maintained, and, also, it has been requested that a quality in recorded signal obtained from being recorded at a low speed is satisfactory. Especially, according to the Part III of
25 the Orange Book which is a specification of standards

for rewriteable compact disks, high-speed recording at a speed four times through ten times, has been being standardized, in contrast to the related art in which recording is made at a speed once through four times.

5 Further, for high-speed recording, it is difficult to apply a constant linear velocity (CLV) form to recording apparatuses in consideration of the apparatus performances. Accordingly, it is necessary to apply a constant angular velocity (CAV) form thereto. In order
10 to apply the CAV recording form, a velocity margin approximately three times is needed for a general optical disk having a diameter of 120 mm.

However, a margin in recording speed has reached a limit for optical information recording media.
15 In particular, for phase-change-type optical information recording media, it has been difficult to widen the margin in recording speed in consideration of property of recording material. Accordingly, optical information recording media which can be used only for high-speed
20 recording result basically. However, actually, when a conventional recording apparatus produced for recording at a low speed is used, and, a recording medium only for high-speed recording is inserted thereto by mistake, a writing process may be forcibly performed on the
25 recording medium after processes such as setting of a

recording power through trial writing and so forth. In such a case, due to a difference in material of optical information recording media between conventional ones for low-speed recording and new recent ones for high-

5 speed recording, it is not possible to perform recording through the recording apparatus produced for recording at a low speed, satisfactorily. Accordingly, original data may be erroneously erased, or nonsense writing may be made.

10 Accordingly, it is necessary that, even from such an optical information recording medium only for high-speed recording, reproducing of recorded data can be performed through a conventional recording apparatus or reproducing apparatus produced for
15 recording/reproducing at a low speed in order that such a recording medium can be used generally and has a compatibility, but, to such a recording medium, recording cannot be performed through such a recording apparatus produced for recording at a low speed.

20

SUMMARY OF THE INVENTION

 An object of the present invention is to provide an optical information recording medium produced for high-speed recording, from which reproducing
25 recorded data can be performed through a conventional

recording apparatus or reproducing apparatus produced for recording/reproducing at a low speed, but, to which recording cannot be performed by such a recording apparatus produced for recording at a low speed.

5 An recordable optical information recording medium, according to the present invention, having addresses t for respective sectors, comprises:

 an area A1 starting from an address t_1 to which access is made by a recording apparatus only at a
10 time of recording operation;

 an area A2 starting from an address t_2 to which access is made by the recording apparatus either at a time of recording operation or at a time of reproducing operation; and

15 an area A3 starting from an address t_3 to which access is made either by the recording apparatus or a reproducing apparatus either at a time of recording or at a time of reproducing, and

 wherein the addresses t are set consecutively
20 with respect to a physical arrangement of the sectors in each of the areas A2 and A3, and the area A1 has at least one inconsecutive part at which the addresses t are not consecutive with respect to the physical arrangement of the sectors.

25 In this configuration, because the addresses t

are set consecutively with respect to the physical arrangement of the sectors for the areas A2 and A3 as in a normal manner, information can be reproduced even from the optical information recording medium produced for recording at a high speed through a conventional recording apparatus produced for recording at a low speed or by a reproducing apparatus. On the other hand, because the area A1 has at least one inconsecutive part at which the addresses t are not consecutive with respect to the physical arrangement of the sectors, an error occurs when the area A1 is accessed at the time of recording operation. Accordingly, it is possible to provide the optical information recording medium produced for recording at a high speed to which recording cannot be performed through a recording apparatus produced for recording at a low speed.

The inconsecutive part may have no sector range between an address $t1'$ and an address $t2'$ which are not consecutive, where $t1 < t1'$, $t2' < t2$, and the starting address $t1$ of the area A1 may be set precedingly by the amount of $(t2' - t1')$.

Accordingly, although the inconsecutive part is provided, no range in which the addresses are not understandable/recognizable exists, and also, it is possible to secure the area A1 equivalent to that in the

case where this inconsecutive part is not provided.

The inconsecutive part may have a range of $A1'$ in the direction of the physical arrangement of the sectors between addresses $t1'$ and $t2'$, the addresses
5 from the address $t1'$ to the address $t2'$ are not consecutive, where $t1 < t1'$, and $t2' < t2$, and arbitrary addresses tx may be set in the range $A1'$.

Thereby, although the inconsecutive part is provided, it is possible to set arbitrary addresses tx
10 in the range of the inconsecutive part. Accordingly, it is possible to utilize the inconsecutive part by setting additional information therein.

The inconsecutive part may have a range of $A1'$ in the direction of the physical arrangement of the
15 sectors between addresses $t1'$ and $t2'$, the addresses from the address $t1'$ to the address $t2'$ are not consecutive, where $t1 < t1'$, and $t2' < t2$, and there may be no addresses set in the range $A1'$.

Thereby, because no addresses exist in the
20 inconsecutive part, it is possible to make an error positively occur at the inconsecutive part when an attempt is made to record information to the recording medium through a conventional recording apparatus produced for recording at a low speed, and, thus, to
25 prevent writing thereto through this recording apparatus.

The recording medium may further comprise a pre-pit in the inconsecutive part.

Thereby, because the pre-pit is provided in the inconsecutive part, it is possible to add
5 information in the inconsecutive part.

The addresses may be recorded in wobbles of a guide groove.

Because the addresses are thus recorded in a form of wobbles of the guide groove of the recording
10 medium, and a track signal is used, it is possible to specify the addresses separately from a recording signal.

The recording medium may be configured to have a characteristic such that, a degree of modulation is equal to or lower than 0.5 obtained when recording is
15 made through the recording apparatus employing either an optical pickup for CD having a wavelength $\lambda = 789$ nm, and a numerical aperture of an objective lens $NA = 0.50$ or an optical pickup for DVD having a wavelength $\lambda = 650$ nm, and a numerical aperture of an objective lens $NA =$
20 0.60, at a relative speed V such that $V = 0.5 V_{min}$ where V_{min} represents the lowest recordable relative speed between the optical pickup and the recording medium, with a recording signal of the largest mark length using a light-emitting waveform comprising a multi-pulse
25 sequence.

Accordingly, whether it is for CD or for DVD, the characteristic such that the degree of modulation is equal to or smaller than 0.5 is obtained when recording is made at the speed $V = 0.5V_{\min}$ which is $1/2$ of the
5 lowest recording speed V_{\min} guaranteed for the recording medium. Therefore, recording to the recording medium cannot be performed properly through a conventional recording apparatus produced for recording at a low speed, consequently, and, as a result, an error occurs
10 such that an OPC error is forwarded in recording of trial writing or the like. On the other hand, the recording characteristic can be improved for $V \geq V_{\min}$ for the recording medium.

A recording apparatus, according to the
15 present invention comprises:

a detecting part which detects as to whether or not the inconsecutive part exists in the area A1 of the above-mentioned recording medium according to the present invention; and

20 a correcting part which performs correlation for the inconsecutive addresses thereof when the inconsecutive part is detected by the detecting part.

In this configuration, when recording to the optical information recording medium having the
25 inconsecutive part in the area A1 produced for recording

at a high speed is performed, the detecting part detects the inconsecutive part, and the correcting part performs address correction for the inconsecutivity of the addressees thereof. Thereby, it is possible for the recording apparatus to access the area A1 without generating any problem, and to perform normal recording processing.

Other objects and further features of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 typically illustrates a sector and address structure of an optical information recording medium in an embodiment of the present invention;

FIGS. 2A, 2B and 2C illustrate three examples of relationship between the number of sectors and address in the optical information recording medium in the embodiment of the present invention;

FIG. 3 illustrates a waveform of a recording signal used in experiments performed for the optical information recording medium in the embodiment of the present invention;

FIG. 4 is a block diagram showing a general

configuration of a recording apparatus in one embodiment of the present invention;

FIG. 5 shows a side elevational sectional view of an example of the optical information recording medium in the embodiment of the present invention; and

FIG. 6 shows an example of relationship between the number of sectors and address in an optical information recording medium in the related general art.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the present invention will now be described based on FIGS. 1 through 5. First, a sector and address structure of an optical information recording medium 1 in the embodiment of the present invention to which data recording at a high speed can be performed will now be described with reference to FIGS. 1 and 2.

Sectors are previously formed in a recording area of the optical information recording medium 1 in the embodiment of the present invention at least before information is recorded thereto, and an address is assigned to each sector. The addresses are ones which can specify the corresponding sectors, respectively. Information concerning these addresses are preferably recorded in a manner in which the information is

modulated into wobbles of a guide groove of the optical
information recording medium 1. For example, ATIP
(Absolute Time In Pregroove) in CD-R disks or CD-RW
disks, and ADIP (Address In Pregroove) in rewriteable
5 DVD+RW disks are examples therefor.

The optical information recording medium 1 has
at least three recordable areas A1, A2 and A3 as shown
in FIG. 1. The area A1 is an area to which a recording
apparatus accesses only at a time of recording operation
10 (at a time of processing operation in prior to actual
recording). An information management area for a
recording apparatus or the like is one example thereof.
As an actual example, an area for trial writing before
recording for setting a recording power for a laser
15 light of an optical pickup for recording (PCA (Power
Calibration Area) in a CD-R disk, CD-RW disk, DVD+RW
disk, or the like) corresponds to the area A1. This
area A1 extends from a starting address t1 to an end
address t2.

20 The subsequent area A2 is an area to which a
recording apparatus accesses at a time of recording
operation and also accesses at a time of reproducing
operation (at a time of processing operation in prior to
actual reproducing). For example, this area is used as
25 an area for managing recorded information in many cases.

As an actual example, a PMA (Program Memory Area) in a CD-R disk and a CD-RW disk corresponds to this area A2. This area A2 extends from a starting address t2 to an end address t3.

5 The subsequent area A3 is an area to which a recording apparatus accesses at a time of recording (at a time of execution of actual recording processing) and at a time of reproducing (at a time of execution of actual reproducing processing), and an apparatus (only)
10 for reproducing accesses at a time of reproducing. To this area, information (data) is actually recorded. A program area in a CD-R disk and a CD-RW disk corresponds to this area A3. This area A3 starts from a starting address t3.

15 For a conventional optical information recording medium produced for recording at a low speed, as shown in FIG. 6, addresses t are consecutively assigned and set according to a predetermined rule, according to a physical arrangement of sectors on the
20 optical information recording medium. That is, a relationship between the physical arrangement of the sectors and addresses is, as shown in FIG. 6, such that, as the number of sectors increases (or decreases), the address increases, and, according to a rule particular
25 to the recording medium, the address always changes

consecutively. A recording apparatus detects an absolute position on the optical information recording medium from the address, and performs recording thereto. However, for an optical information recording medium
5 produced for recording at a high speed, if the sector and address structure shown in FIG. 6 is applied thereto, there is a possibility that even an apparatus produced only for recording at low speed can also perform recording thereto forcibly.

10 In this point, the optical information recording medium 1 in the embodiment of the present invention has the area A1 which is accessed only at a time of recording operation and is previously formatted so that at least one inconsecutive part at which the
15 addresses t are not consecutive with respect to the physical arrangement of sectors is provided. This inconsecutive part is set between an address $t1'$ through an address $t2'$. These addresses $t1'$ and $t2'$ are those such that $t1 < t1' < t2' < t2$ in the area A1.

20 The addresses $t1'$ and $t2'$ of the inconsecutive part are determined based on a point at which a recording apparatus produced for recording at a low speed, for which recording thereto is to be prevented, accesses in the area A1. For example, when the
25 recording apparatus produced for recording at a low

speed accesses an address t_0 in the area A_1 at a time of recording operation, the addresses t_1' and t_2' are set so that the above-mentioned address t_0 is in the inconsecutive part, that is, this address t_0 is included
5 between the address t_1' through t_2' .

A form of this address-t inconsecutive part may be set arbitrarily. FIGS. 2A, 2B and 2C show three typical examples in pattern of the form of the address-t inconsecutive part. FIG. 2A shows a pattern in which
10 the inconsecutive part 2 has no sector range. In this example, no sectors exist between the addresses t_1' and t_2' , as shown in FIG. 2A, and thereby the addresses are not consecutive at this inconsecutive part 2. In this case, in comparison to the address setting in the
15 general related art shown in FIG. 6, the number of sectors included in the area A_1 is smaller by the number corresponding to the addresses t_1' through t_2' of the inconsecutive part 2. Therefore, the starting address t_1 of the area A_1 is set precedingly for this difference
20 (reduction). Specifically, $t_1 - (t_2' - t_1')$ is set as the starting address of the area A_1 in this case. According to this arrangement, it is possible to form the inconsecutive part 2 at which the addresses t are not consecutive without decreasing the number of useable
25 sectors included in the area A_1 , and, also without

providing any area in which the address t are not understandable/recognizable.

FIG. 2B shows an exmaple in which the inconsecutive part 3 at which the addresses t are not consecutive is formed having a range A1' in the direction of the physical arrangement of sectors. In this case, arbitrary addresses tx can be freely set in the range A1' of the inconsecutive part 3. Accordingly, by setting arbitrary addresses tx in the inconsecutive part 3, it is possible to cause the range A1' to have additional information using the addresses tx such as description of the type of recording medium, or the like in the inconsecutive part 3 at which the addresses t are not consecutive.

FIG. 2C shows an example in which the inconsecutive part 4 is formed similar to the above-mentioned inconsecutive part 3 shown in FIG. 2B. However, the range A1' of the inconsecutive part 4 has no addresses t. For example, in order to cause the inconsecutive part 4 to have no addresses, in a case where the addresses are recorded through wobble modulation of a pregroove (guide groove), wobble modulation is not made, the wobbles themselves are not provided, or the pregroove itself is not provided therein. When the pregroove itself is not provided

therein, a pre-pit may be set in the area A1 so as to prevent track removal when the range A1' of the inconsecutive part 4 is long. In this case, it is possible to arbitrarily set information to be recorded
5 in the pre-pit. By providing the inconsecutive part 4 having no addresses, it is possible that an error is positively caused to occur when an attempt of recording to the optical information recording medium 1 is made through a recording apparatus produced for recording at
10 a low speed, as described later.

A medium property of the optical information recording medium 1 in the embodiment of the present invention is improved so that recording thereto at a high speed can be rendered. However, it is preferable
15 that the following setting is made such that recording through a recording apparatus produced for recording at a low speed can be positively prevented. That is, when an optical pickup for CD of wavelength $\lambda = 789 \text{ nm}$ and numerical aperture of objective lens $NA = 0.50$ or an
20 optical pickup for DVD of wavelength $\lambda = 650 \text{ nm}$ and numerical aperture of objective lens $NA = 0.60$ is used, it is preferable that characteristics obtained when recording is performed at a relative speed which is $1/2$ of the lowest speed V_{min} guaranteed for the recording
25 medium (lowest recordable relative speed) between the

pickup and recording medium, that is, $V = 0.5V_{min}$, are as follows. In this case, as a recording signal, as shown in FIG. 3, a multi-pulse sequence including repetitions of heating pulses and cooling pulses, and, having the maximum mark length of $11T$. The recording power P_w is set arbitrarily, and, the erasing power P_e is set as $0.5P_w$. In this condition, the degree of modulation m_{11} ($= I_{11}/R_{top}$, where R_{top} represents the maximum reflectance for a portion at which information is not written, and I_{11} represents the reflectance for a portion at which the maximum mark length $11T$ is recorded) is measured when the signal recorded to the optical information recording medium 1 is reproduced by using the optical pickup used in the recording, and the degree of modulation m_{11} is such that $m_{11} \leq 0.5$. In the optical information recording medium 1 having the above-mentioned characteristics, it is possible to increase the degree of modulation at the maximum recording speed V_{max} guaranteed for the recording medium, and to obtain stable characteristics of recorded signal when recording is performed at a high speed.

A recording apparatus 5 in an embodiment of the present invention which can perform recording information to the optical information recording medium 1 to which recording can be performed at a high speed

will now be described with reference to FIG. 4.

Basically, a configuration for preventing the above-mentioned inconsecutive part 2, 3 or 4 from having any influence at a time of recording operation is provided.

5 In this recording apparatus 5, although details are omitted, an optical pickup 7 including a laser light source, an objective lens, a photodetector and so forth for applying a light beam for recording or reproducing to the optical information recording medium 1 which is
10 driven and rotated by a spindle motor 6, a read-signal processing part 8 which performs extraction of an address signal from a read signal detected by the photodetector of the optical pickup 7, an address-signal processing part 9 which performs demodulation processing
15 on the address signal obtained from the read-signal processing part 8, an address-inconsecutivity detecting part 10 which detects whether or not address inconsecutivity exists, based on the output of the address-signal processing part 9, an address correcting
20 part 11 which performs predetermined address correction when address inconsecutivity is detected by the address-inconsecutivity detecting part 10, and a recording-apparatus control part 12 provided for controlling the laser light source in the optical pickup 7.

25 In the above-mentioned configuration of the

recording apparatus 5, the light beam is condensed and applied to the optical information recording medium 1 which is driven and rotated by the optical pickup 7, the reflected light from the optical information recording medium 1 is received by the photodetector, and, thereby, a signal is read out from the optical information recording medium 1. Only an address signal is extracted from the thus-read signal by the read-signal processing part 8. The thus-extracted address signal is demodulated by the address-signal processing part 9, and, thereby, a point at which the light beam is currently applied to the optical information recording medium 1 is specified. At this time, in a recording apparatus produced for recording at a low speed in the general related art which does not have the address-inconsecutivity detecting part 10, when address inconsecutivity occurs as a result of the inconsecutive part 2, 3, or 4 being accessed, it is determined that tracking failure has occurred, and an error signal is forwarded to the recording-apparatus control part 12. Accordingly, it is not possible that subsequent processing, that is, trial writing and recording processing which is to be performed in a normal state, cannot be performed. Thereby, writing of information to the optical information recording medium 1 is prevented

from being performed by the recording apparatus produced for recording at a low speed.

In contrast to this, in the recording apparatus 5 in the embodiment of the present invention described with reference FIG. 4, the address-inconsecutivity detecting part 10 and address correcting part 11 are provided, and address information concerning the inconsecutive part 2, 3 or 4 in the area A1 of the optical information recording medium 1 is previously recognized. Accordingly, when address inconsecutivity occurs at an access to the area A1, the address-inconsecutivity detecting part 10 recognizes that the address inconsecutivity has occurred due to the inconsecutive part 2, 3 or 4, and outputs this matter to the address correcting part 11. As a result, the address correcting part 11 performs address correction such that the addresses at the inconsecutive part 2, 3 or 4 are skipped, and then, outputs address information to the recording-apparatus control part 12. Thus, without being affected by the address inconsecutivity due to the inconsecutive part 2, 3 or 4, and, through predetermined control by the recording-apparatus control part 12 or the like, trial-writing processing by accessing the area A1 (setting of the recording power Pw) and so forth is performed. Thereby, it is possible

to perform recording processing to the area A3 or the like, which is to be performed in the normal state.

With regard to reproducing processing performed through a recording or reproducing apparatus, 5 whether it is produced for recording at a low speed or a high speed, no access to the area A1 is performed, and, access to the areas A2 and A3 in which the addresses t are set consecutively according to the physical arrangement of sectors is performed. Therefore, 10 reproducing processing can be rendered without occurrence of any problems.

At least the above-described processing performed by the address-inconsecutivity detecting part 10 and address correcting part 11 may be performed by a 15 general-purpose computer as a result of instructions written in a software program including program code means for performing the processing to be executed thereby. The software program may be recorded in a carriable recording medium such as a CD-ROM, which is 20 read therefrom through a CD-ROM drive, and is provided to the CPU of the computer. Then, the CPU performs the processing according to the program.

Actual examples of the above-described of the optical information recording medium 1 in the embodiment 25 of the present invention described above will now be

described.

<First Example>

A substrate for a CD-RW was prepared in which, on a transparent substrate made of polycarbonate, a continuous guide groove was formed spirally. For address information (ATIP) to be recorded in the guide groove, the inconsecutive part 2 of ATIP inconsecutivity in a form as shown in FIG. 2A was formed at the address t1' and t2' in the following manner:

10

t1 = 96 : 25 : 10

t1' = 96 : 41 : 49

t2' = 97 : 11 : 50

t2 = 97 : 23 : 50

15

t3 = 97 : 27 : 00

An area in which the above-mentioned inconsecutive part 2 was formed is a PCA, which is an area to which trial writing is performed with the power being changed, in order to determine the recording power Pw, at a time of recording operation, by a recording apparatus. The addresses t1' and t2' were determined in consideration of a position at which the recording apparatus accesses at a time of the recording operation.

25

Further, for the area other than the

inconsecutive part 2, ATIP information which can be used
for 1 through 4 times (1X through 4X) of a normal
reproduction speed of a compact disk which is produced
in accordance with the Orange Book, Part III, ver. 2.0,
5 which is the specification of standards for CD-RW was
recorded thereto.

Then, as shown in FIG. 5, onto the thus-
obtained transparent substrate 13, a lower dielectric
layer 14, a recording layer 15, an upper dielectric
10 layer 16, a metal reflection layer 17 and a protection
layer 18 were formed. Thus, the optical information
recording medium 1 was obtained. Each of the lower and
upper dielectric layers 14 and 16 were made of a mixture
mainly containing ZnS and SiO₂, the recording layer 15
15 was made of a phase-change material mainly containing
AgInTeSb, and the metal reflection layer 17 was made of
a material mainly containing Al. Further, the lower and
upper dielectric layers 14 and 16 were formed by RF
sputtering, and the recording layer 15 and metal
20 reflection layer 17 were formed by DC sputtering. The
protection layer 18 was formed as a result of a film of
a UV curing resin being deposited by spin coating, and
then, UV light being applied thereto so as to cure it.

By initializing the thus-obtained optical
25 information recording medium 1 through a CD-RW

initializing apparatus, it was possible to obtain a not-yet-recorded CD-RW recording medium. Thus-obtained recording medium has the above-mentioned inconsecutive part 2 at which addresses are not consecutive formed in the PCA area.

An experiment was performed so as to determine whether or not recording can be made to this CD-RW recording medium having the inconsecutive part 2 at which addresses are not consecutive in the PCA area as mentioned above, through a recording apparatus (produced for recording at a low speed) available at stores. The recording apparatus used is a CD-R/RW drive MP-7060A made by Ricoh Company Ltd. When an attempt was made to record information to the CD-RW recording medium through this recording apparatus, an error occurred at an initial stage of recording operation, and the recording medium was ejected by the apparatus.

On the other hand, the above-mentioned recording apparatus was modified so as to additionally include the above-mentioned address-inconsecutivity detecting part 10 and address correcting part 11, and, then, the attempt was made to record information to the CD-RW recording medium (optical information recording medium 1) through this modified recording apparatus. As a result, although inconsecutivity of ATIP exists in the

PCA area due to the inconsecutive part 2, the address
correcting part 11 performed correction for the
addresses for 00 : 30 : 00 in the inconsecutive part 2
which are not consecutive. Thereby, recording operation
5 such as trial writing and so forth was performed without
occurring any problem, and, then, actual recording was
started by the recording apparatus. Thus, it was
confirmed that, while recording can be performed to the
optical information recording medium 1 in the embodiment
10 of the present invention through the recording apparatus
5 in the embodiment of the present invention, recording
cannot be performed to the same optical information
recording medium 1 through the original (not modified)
recording apparatus produced for recording at a low
15 speed.

<Second Example>

A CD-RW recording medium was produced in a
manner similar to that in the case of the above-
20 described first example. However, the composition ratio
of the material of the recording layer thereof was
changed so that recording at a high speed such as 4X
through 8X can be performed thereon. Then, a CD-RW disk
evaluating apparatus DDU1000 ($\lambda = 789 \text{ nm}$, $\text{NA} = 0.50$) was
25 used, and recording was performed on the thus-produced

CD-RW recording medium at speeds of 8X ($V = 9.6$ m/s), 4X
($V = 4.8$ m/s) and 2X ($V = 2.4$ m/s) with the recording
signal of multi-pulse waveform shown in FIG. 3. The
recording power P_w was determined by an OPC method which
5 is in accordance with the Orange Book, Part III, ver.
2.0, which is the specification of standards for CD-RW.

The thus-recorded signals were read at a
reproduction speed of 1X, and the above-mentioned degree
of modulation m_{11} for each recording speed was measured.
10 As a result, the following results were obtained:

$$8X: I_{11}/R_{top} = 0.65$$

$$4X: I_{11}/R_{top} = 0.56$$

$$2X: I_{11}/R_{top} = 0.45$$

15

Thus, the sufficient degrees of modulation
were obtained for the recording signals for the
recording speeds of 8X and 4X. However, the degree of
modulation was low for a low speed such as 2X in a
20 conventional manner, and is lower than 0.55 which is the
lowest standard value for CD-RW. Accordingly, the
optical information recording medium 1 in the embodiment
of the present invention is a recording medium to which
recording cannot be performed properly at a low speed
25 such as 2X.

Then, when an attempt was made to write information to the above-mentioned CD-RW recording medium through the above-mentioned conventional recording apparatus which was not modified and thus does
5 not have the address-inconsecutivity detecting part 10 and so forth and was used for the above-mentioned first exmapple, the CD-RW recording medium was ejected by the recording apparatus before recording is made, similarly.

The present invention is not limited to the
10 above-described embodiments, and variations and modifications may be made without departing from the scope of the present invention.

The present application is based on Japanese priority application No. 2000-058081, filed on March 3,
15 2000, the entire contents of which are hereby incorporated by reference.